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The Effect of Landfills on Rural Residential Property Values: Some Empirical Evidence

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Abstract. The question of whether solid waste landfills affect residential property values has long been a subject of debate. Past research has resulted in mixed conclusions. The current study examines six landfills, which differ in size, operating status, and history of contamination. The effect of each landfill is estimated by the use of multiple regression. In five of the landfills, no statistically significant evidence of an effect was found. In the remaining case, evidence of an effect was found, indicating that houses in close proximity to this landfill suffered an average loss of about six percent in value.

1. Introduction

The United States is one of the leading solid waste generators in the world. Estimates from the Environmental Protection Agency predict that by the year 2010, the United States will be generating municipal solid wastes at the unprecedented rate of 250 million tons per year (US EPA, 1990). Despite recent improvements in recycling and incinerating techniques, the sanitary landfill remains the most widely used method of disposal.

The question of whether solid waste landfills affect residential property values has long been a subject of debate. The hedonic technique, which attempts to infer people's preferences by the way they behave in the market, has been used in the past for this purpose, with widely differing results. This

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study attempts to determine whether the hedonic technique is appropriate to study questions of this nature. If it proves to be, the second goal of this study is to determine whether the size of the price effect differs according to certain characteristics of the landfill. In other words, it maybe certain characteristics of the landfill, such as the size, operating status, and history of contamination, which have an effect on surrounding property values, not the mere presence of one.

Apart from possible environmental damages associated with landfills, such as groundwater contamination and the accumulation of methane gas, residents fear that their property values may be adversely affected if a landfill is sited nearby. If a landfill has already been operating for some time, residents of the host community may fear that the continued operation of that landfill can imperil their future health or well-being. In these cases, the landfill may be forced to cease operations and the town (and ultimately the tax payers) may have to absorb the costs of shipping the town's waste to a neighboring town's landfill or transfer station. However, residents' perceptions are not necessarily based in reality. If a town landfill is poorly maintained, not monitored, and leaks into the town's water supply, it will not affect property values if people are not aware of it. If, on the other hand, a landfill is lined, well policed for litter, vermin and other nuisances, and does not leak into groundwater, it still may be perceived as a threat to human health. These perceptions can translate into depreciation of property values. If people feel that the landfill potentially is a risk to their family's health, they may choose to relocate (or simply not buy properties close to landfills). This desire will be reflected in the market value of the house. The buyer of that house will presumably be less risk averse than the sellers, and will be prepared to accept a modicum of risk in return for paying a lower price. If the entire community feels that the landfill poses a threat, housing prices in the community as a whole potentially may decrease. This in turn translates to a lower tax base, which leads to a lower level of services.

The situation is doubly severe in rural areas. Pressed for capital already, the threat of decreasing property values and a lower tax base is definitely a concern. Many of the landfills in rural areas are small and closed, but still may affect property values. If it can be shown that landfills do not affect property values, or that only certain types of landfills have such an effect, that information may assist town planners in making decisions. For example, if open landfills have more of an effect on property values than closed, planners may consider closing the town landfill and spending the capital needed to ship their waste elsewhere. If leaky landfills have a greater effect than "clean" landfills, that may be an added incentive to increase monitoring, or to conduct remedial activities on existing cells. Finally, if a landfill which is relatively well-run has more of an effect than a potentially hazardous landfill, then planners might try a public relations campaign to bring the public's perception more into line with reality.

2. Previous Work

The hedonic technique has been used in the past to determine the "implicit price" of non-market goods, ranging from air pollution (Ridker and Henning 1967) to historic districts (Coffin 1989) to traffic externalities (Hughes and Sirmans 1992). Studies attempting to measure the effects of landfills, however, have resulted in inconclusive evidence.

Havlicek, Richardson and Davies (1971) analyzed 182 single-family house sales between 1962 and 1970 surrounding four landfills in the Fort Wayne, Indiana region. Their variables of interest were both the linear distance from the nearest landfill and the deviation (in absolute degrees) from the prevailing downwind direction from the landfill. Both the distance and the wind variables were of the hypothesized sign; both were significant at the five percent level. Their results indicated that for each degree away from downwind, the value of the house increased by about $10.30. For each foot of distance away from the site, price increased by about $.61 in a linear fashion.

Nelson et al. (1992) estimated the effect of one landfill in Minnesota on 708 surrounding property values. They found that the landfill had a large negative effect on property values--about 12 percent at the landfill's boundary and about 6 percent one mile away.

Hite (1995) used a year of real estate transaction data to determine the effects of distance from three landfills on properties in Ohio. She discovered that, as hypothesized, distance had a positive effect on the property values studied. However, she also attempted to differentiate between the life expectancies of the landfills. She found that the life expectancy of the landfill made a difference in the magnitude of the landfill's effect on property values.

Zeiss and Atwater (1989) studied the effects of a 200-acre landfill in Tacoma, Washington, on 665 residential properties sold between 1983 and 1986. There were three distinct neighborhoods within the area, leading the authors to run three separate regressions. Their results were statistically insignificant at the five percent level in two of the three cases; in the remaining case, the results were statistically significant, but indicated that the landfill had a *positive* effect on the surrounding property values. In that case, a new development complex had been constructed directly adjacent to the landfill.

An annotated bibliography prepared by Clarion Associates (1991) shows that out of six regression analyses of property values, one found that the landfill had a negative effect on property values, four found no evidence of an effect, and one found a positive effect. Another survey by Zeiss and Atwater (1989) showed six cases that confirm a negative effect, eight cases that show no effect, and one case showing a positive effect.

Hite's 1995 study was the only study that even considered site-specific characteristics of a landfill when determining its effect. There is no reason to believe, however, that a large, active landfill with a history of contamination would have the same effect on property values as a small, closed, lined landfill. In fact, site-specific characteristics may be one of the largest determinants of whether a landfill affects property values. This may explain the mixed results.

In addition, all of the landfill studies to date have been in urban or heavily populated areas. However, sanitary landfills located in rural areas are deserving of attention as well. Recently, many landfills located in rural areas have been closing as small towns consolidate their municipal waste. Many small towns, especially in New England, are growing rapidly. In many of these towns, the only land that remains undeveloped is the land surrounding the landfill. Therefore, it is necessary to study the effects (if any) of small, closed landfills as well as open, operating ones on surrounding property values.

For these reasons, a study that attempts to differentiate between landfills exhibiting varied operating characteristics and a study of landfills in semi-rural areas needs to be undertaken. This study endeavored to meet both needs.

3. Data Collection and Methods

This study collected data on 385 single-family home sales in Massachusetts from January 1992 to August 1995. The six towns studied were Belchertown, Hudson, Ware, Clinton, Pepperell and Leicester, all semi-rural towns located in central and western Massachusetts. These towns were chosen as a result of a two-tier selection process. First, landfills that differed in certain characteristics (size, operating status, and history of contamination) were isolated. Second, towns that were relatively similar in population and median income were selected. It was hoped that any difference in the landfills' effects on property values could be attributed to the characteristics of the landfill, not to the town itself, could be isolated. Table 1 summarizes the characteristics of the landfills studied, and will give an indication of which landfills are expected to have the largest effect on property values.

The Multiple Listing Service of Eastern Metropolitan Massachusetts, a voluntary service provided by and for real estate agents in eastern Massachusetts, provided housing transaction data, such as the date of sale, the sale price, and structural characteristics of the house. Town street maps were then used to identify those houses that were located within two miles of the landfill.[1] Using tax maps provided by the town assessor's office, those houses were then precisely located and plotted on US Geological Survey Maps. Straight-line distances from each house to the landfill, the central

[1] Two miles has been established by the literature as perhaps the upper bound of the area affected by the landfill. See, for example, Nelson et al, 1992.

business district (the town hall was used as a proxy), and the nearest primary highway were then measured.

Although the Pepperell landfill is inactive and relatively small, the fact that it was on the Environmental Protection Agency's "potential threat list" at the time of the study made it suspect as a cause of property devaluation. The Ware landfill would seem to be less suspect due to its small size and the fact that it had never been fined or had any other environmental citations at the time of the study. However, it very well could be that the Ware landfill has more of an effect on property values than the Pepperell landfill, merely because of its "active" status.

Table 1. Landfill and Town Characteristics

Host Town	Population*	Median Income*	Size	Status	History
Pepperell	10,098	$17,191	12.5 acres	I, UL, UC	On EP potential threat list; Some volatile organic compounds found, moderate to heavy litter
Hudson	17,233	$45,191	80 acres, 74,444 tpy	O, PL, UC	Some leachate seeps; assessed civil penalty: leachate tanks overflowing, significant litter nuisance
Belchertown	10,579	$38,868	10 acres	C, UL, PC	Assessed a civil penalty; leachate tanks overflowing, significant litter nuisance
Clinton	13,222	$34,091	55 acres	C, UL, Cp	Not complying with ground water regulations; cap not maintained properly
Leicester	10,191	$15,806	35 acres	C, UL, Cp	Assessed a civil penalty; some contaminants, but "not alarming"
Ware	9,808	$29,425	1,560 tpy	O, UL, UC	Appears to be in good condition; no violations

*US Bureau of the Census, 1990

LEGEND:
tpy = tons per year; PL = partially lined; O = open and active; Cp = capped; C = closed; I = inactive; PC = partially capped; UL = unlined; UC = uncapped

4. The Model

Using Ordinary Least Squares (OLS), inflation adjusted housing prices were regressed upon the series of characteristics described in Table 2. These variables have been used in various property value studies (See, for example, Reichert 1991; Nelson et al. 1992; and Hite 1995); however, the functional form of the hedonic property value equation has been the subject of much debate.

Various functional forms have been used in previous hedonic studies, since functional form is not necessarily dictated by theory. Early researchers typically experimented with several functional forms (usually linear, logarithmic, or semi-log), then selected among these forms on the basis of goodness of fit criteria (Freeman 1993; Cropper et al. 1988). However, use of the linear form effectively imposes independence on the explanatory variables chosen, while in a log form parameter estimates make the implicit prices of characteristics dependent upon the levels of other characteristics. These effective restrictions may not hold, and may even bias study results; Milon et al. (1984, 386) found that "linear or logarithmic restrictions on functional form would severely underestimate the welfare loss" involved in their study of shoreline accessibility. In any case, the question of functional form may be answered by the data itself, using various transformations of the dependent and independent variables. As Freeman (1993, 374) points out, "[t]he only obvious general restriction on the form of the hedonic price equation is that its first derivative with respect to an environmental characteristic be positive (negative) if the characteristic is a good (bad)." Exploratory research using a Box-Cox transformation of the Belchertown data sub-set suggested that a double log form might be appropriate for the problem (Halstead, Hansen, and Bouvier 1997). However, Halvorsen and Pollakowski's results (1981), using likelihood ratio tests, strongly rejected all common functional forms. While the Box-Cox transformation allows the form of an equation to fit the data without imposing prior restrictions, it has been pointed out that the best-fit criterion may not lead to the most accurate results for changes in the marginal price of a particular characteristic, as the independent variable of interest may play only a minor role in determining overall price variation. If this is the case, then it is likely that it also plays only a minor role in determination of the best functional form fit. The flexibility of the Box-Cox approach has been criticized for being purchased at the expense of other goals of the hedonic method (Cassel and Mendelsohn 1985). Coefficients resulting from Box-Cox transformation are dependent on the levels of the other variables, therefore, individual slopes are difficult to determine (Cassel and Mendelsohn 1985; Milon, et al. 1984). It follows that the flexibility provided by the Box-Cox approach may reduce the accuracy of a single coefficient thereby implying that it is a poor estimator of specific prices.

The semi-log form used in two-stage least squares is the most popular alternative to the Box-Cox transformation (Mendelson 1984; Michaels 1990;

Graves et al. 1988; Brown et al. 1977; Bouwes et al. 1979; Murdoch and Thayer 1988; Young and Teti 1984: Wilman 1984). The semi-log form implies that marginal price for those goods that affect total price positively is monotonically increasing (Nelson 1978; Garrod and Willis 1992). In light of this uncertainty, a semi-log reciprocal transformation was used in this study. This functional form was chosen because it had could be supported theoretically. It reflects the belief that the independent variables have a proportional, not a linear, effect on the price of the house. Based on these previous studies and the aforementioned work on functional form for these data, the model used in this paper will be the following (see table 2):

$$\begin{aligned} LNPRICEi = {} & ß_0 + ß_1\, MILF_i + ß_2\, MICBD_i + ß_3\, MIHWY_i + ß_4\, AGE_i + ß_5\, AGE^2_i \\ & + ß_6\, BDRMS_i + ß_7\, OTHRMSi + ß_8\, BTHRM_i + ß_9\, LNLTSZ_i \\ & + ß_{10}\, FPLACE_i + ß_{11}\, GARAGE_i + ß_{12}\, POOL_i + ß_{13}\, SOLD92_i \\ & + ß_{14}\, SOLD93_i + ß_{15}\, SOLD94_i\ . \end{aligned} \tag{1}$$

Note that the variables for distance to landfill (MILF), distance to central business district (MICBD), and distance to major highway (MIHWY) are all inverses; this effectively imposes a "decay" effect as properties are located further from these (dis)amenities. For example, this transformation allows for the presumed negative effect of a landfill on property values to "die out" since as distance to the landfill increases the value of the MILF variable asymptotically approaches zero. This effect would seem to be theoretically justified, as beyond some distance any amenity or disamenity would cease to have an appreciable effect. Finally, SOLD92, SOLD93, and SOLD94 are dummy variables for the year in which the house was sold. These variables also include temporal fixed effects, as well as macroeconomic conditions.

Table 2. Variables included in the Landfill Property Value Model

Variable Name	**Description [Hypothesized sign]**
LNPRICE	Log of the price (in 1995 dollars)
MILF	Inverse of the distance to the landfill (in miles)[negative]
MIHWY	Inverse of the distance to the nearest primary highway (in miles) [indeterminate]
MICBD	Inverse of the distance to the central business district (in miles) [indeterminate]
AGE	Age of the house [negative]
AGE^2	Age squared of the house [positive]
BDRMS	Number of bedrooms [positive]
OTHRMS	Number of other rooms [positive]
BTHRM	Number of bathrooms [positive]
LNLTSZ	Log of the lot size (in feet)(positive]
FPLACE	Dummy variable for a fireplace [positive]
GARAGE	Dummy variable for a garage [positive]
POOL	Dummy variable for a pool [positive]
SOLD92	Dummy variable for if the house was sold in 1992 [indeterminate]
SOLD93	Dummy variable for if the house was sold in 1993 [indeterminate]
SOLD94	Dummy variable for if the house was sold in 1994 [indeterminate]

5. Data and Statistical Issues

Collinearity is frequently a concern in hedonic models. This problem was addressed *a priori* through variable selection; this explains why number of rooms was included as an explanatory variable while square footage of the dwelling was excluded. Once the variables were selected, condition numbers for the data matrix were examined. These ranged from 59.3 (Ware) to 104 (Hudson) for the six towns; only the Hudson data set had a condition number greater than 100. Gujarati (1995) notes that condition numbers between 100 and 1,000 are consistent with moderate to strong collinearity; since all five of the six data sets had condition numbers below 100, collinearity was not considered a problem in these models. Collinearity is usually considered as a matter of degree rather than in terms of presence or absence. The condition numbers in this study were well below the 1,000 and above level, which is considered severe or degrading.

Heteroskedasticity was also a concern, as large houses may have different variances in price than small houses. Goldfeld-Quandt tests showed no evidence of heteroskedasticity, while Breusch-Pagan-Godfrey tests did reveal evidence of heteroskedasticity in one data set (Pepperell; ?^{2} = 82.41; critical ?^{2} = 30.58). However, given the behavior of the variables that appeared to be the "culprits" (AGE and AGE^2) (and the relatively small Pepperell data set [n = 59]), it was decided that the OLS coefficient estimates were still appropriate here; corrected (White) standard errors are reported in Table 3.

6. Pooling the Data Sets

One of the objectives at the onset of this study was to pool the data sets from the six towns, for two reasons: first, given the relatively small data sets for each town, pooling would provide a larger sample and thus improve the efficiency of the coefficient estimates; and second, to allow for the inclusion of independent variables to specifically examine the effects of different landfill characteristics such as open vs. closed, leaky vs. clean, large vs. small, etc. To this end, a Chow test was performed that allowed the intercepts and the landfill variables to vary. This permitted the existence of town effects (quality of the school system, tax rate, town services provided) and allowed the effect of the landfill to vary from town to town. This last was accomplished by creating a town dummy and interacting that with the landfill variable.

The results of the F test showed that the six towns were not similar enough to be pooled. Statistically, this limits any extrapolation of results to other areas. However, this result is of interest in itself: it indicates that even small, rural, similar towns from the same state differ enough that the landfill problem should be approached on a town by town basis. The fact that the Chow tests do not support pooling indicates that the housing market may differ substantially from town to town. The intercept was meant to have captured any town specific effects, such as school and service quality and tax rate, but if the structure of the housing markets differs, the intercept would not necessarily capture the difference.

Table 3. Results of Landfill Property Value Model

TOWN	PEPPERELL	HUDSON	BELCHERTOWN	CLINTON	LEICESTER	WARE
Adj. R^2	0.5506	0.7335	0.7034	0.5466	0.4127	0.6215
F stat:	5.737	11.275	16.881	5.662	3.115	8.225
Prob> F:	0.0001	0.0001	0.0001	0.0001	0.0033	0.0001
Number of obs.	59	47	101	59	46	67
Variable	**Coefficient Variable (Standard Error)[a]**					
Intercept	10.0756***	9.8012***	10.4123***	11.0511*	10.8524***	9.9469***
	(0.3842)	(0.3795)	(0.2798)	(0.5332)	(0.4942)	(0.3218)
MILF1	-0.0627*	-0.0280	-0.0065	-0.0099	0.2558	0.0073
	(0.0354)	(0.0486)	(0.0271)	(0.0207)	(0.1588)	(0.0309)
MICBD1	0.0386	0.0522***	-0.0085***	0.0298***	-0.0082	-0.0139
	(0.0367)	(0.0193)	(0.0265)	(0.0167)	(0.0238)	(0.0249)
MIHWY1	0.0001	-0.0017	-0.0008	-0.0012	-0.0038**	-0.0012
	(0.0008)	(0.0016)	(0.0010)	(0.0022)	(0.0018)	(0.0022)
AGE	-0.0021	-0.0057***	-0.0045***	-0.0083***	-0.0086**	-0.0028
	(0.0050)	(0.0015)	(0.0014)	(0.0047)	(0.0032)	(0.0018)
AGE^2	0.0000	0.00002**	2.16e-04***	0.000053	0.0004*	4.86e-05
	(0.0002)	(0.00001)	(7.15e-05)	(0.000039)	(0.0002)	(1.00e-04)
BDRM	0.0650**	0.1063**	0.0730***	0.0576***	-0.0178	0.0920***
	(0.0315)	(0.0403)	(0.0246)	(0.0323)	(0.0234)	(0.0326)
OTHRM	0.0169	0.0213	0.0843***	0.1069*	0.0078	0.0445*
	(0.0246)	(0.0180)	(0.0191)	(0.0348)	(0.0314)	(0.0244)
BTHRM	0.1236***	0.0041	0.1191***	-0.036	0.1610	0.0235
	(0.0345)	(0.0471)	(0.0381)	(0.0611)	(0.0819)	(0.0406)
LNLTSZ	0.1171***	0.1639***	0.0601**	0.0255	0.0056	0.01066***
	(0.0316)	(0.0370)	(0.0265)	(0.05122)	(0.0419)	(0.0305)
GRACE	0.1107***	0.0397	0.0183	0.1298**	0.0629	0.1602***
	(0.0316)	(0.0427)	(0.0351)	(0.0552)	(0.0679)	(0.0547)
FPLACE	0.0896**	0.0624**	0.0008	0.0842	0.0935*	0.0633
	(0.0414)	(0.0284)	(0.0330)	(0.0625)	(0.0534)	(0.0477)
POOL	0.0194	0.0901*	0.0660	-0.0160	0.2151*	0.0564
	(0.0661)	(0.0522)	(0.0599)	(0.1040)	(0.1118)	(0.0781)
SOLD92	-0.0086	0.1888**	0.1039**	0.1018	-0.0268	0.0681**
	(0.0427)	(0.0767)	(0.0478)	(0.0955)	(0.2175)	(0.0787)
SOLD93	0.0262	0.0759	0.0260	-0.0284	-0.0078	0.0336
	(0.0526)	(0.0549)	(0.0453)	(0.0756)	(0.2233)	(0.0843)
SOLD94	0.0528	0.0756	0.0344	-0.0992	-0.0243	-0.1101
	(0.0430)	(0.0527)	(0.0445)	(0.0775)	(0.2156)	(0.0795)

[a] White corrected standard errors
***statistically significant at the 99% level
**statistically significant at the 95% level
*statistically significant at the 90% level

7. Results of Individual Regressions

Results of each regression are summarized in Table 3. F-statistics for all six models indicate that all were significant at the one percent level. The more salient features of the regressions are highlighted here. Three of the data sets (Pepperell, Clinton and Hudson) showed evidence of model misspecification when Ramsey ReSET tests were performed. Some *ex post* tests were then performed on the functional form of the model to determine if the Ramsey ReSET tests would yield different results under different functional forms. However, the results did not change significantly. Therefore, the model remains in its current form, with a cautionary word as to the presence of misspecification in three of the models.

The Pepperell data set generated an adjusted R^2 of 0.5506 and an F statistic of 5.737, indicating that the null hypothesis (the model explains none of the variation in housing price) can be decisively rejected. As noted below, since Pepperell was the only model where heteroskedasticity was present, corrected (White) standard errors are reported with the results in Table 3. All of the variable coefficients had the hypothesized sign. The landfill variable coefficient is negative, as hypothesized, and it is statistically significant at the ten percent level.

In Hudson, although the adjusted R^2 of 0.7335 attests to the predictive power of the model, the distance to the landfill variable coefficient was not statistically significant at the five or ten percent level (although it did have the hypothesized sign). There is nothing unexpected in the model; most of the estimated coefficients were statistically significant and had the hypothesized sign.

The Belchertown data set yielded an adjusted R^2 of 0.7034. Of the nine structural characteristics, six were significant at the five percent level and had the hypothesized sign. Although the estimated coefficient on the landfill variable is the hypothesized sign, a 95 percent confidence interval around the estimated coefficient does include zero. Thus, there is no statistically significant evidence of an effect of the Belchertown landfill on the surrounding property values.

In the Clinton data set, only two variable coefficients emerged statistically significant at the five percent level and three more variables were significant at the ten percent level. The Clinton model's adjusted R^2 is 0.5466. Again, the distance from the landfill variable coefficient is of the hypothesized sign, but statistically insignificant.

Leicester's regression resulted in an adjusted R^2 of only 0.4125. This means that the model has the weakest explanatory power of the six towns; however, it is still statistically significant at the five percent level. The coefficient on the landfill variable is <u>positive</u>, which is contrary to expectations (although it is statistically insignificant at the five percent level). Two of the variable coefficients in Leicester's regression are statistically significant at the five percent levels; four are statistically significant at the ten percent level.

In Ware, although the adjusted R^2 of 0.6215 indicated that the model has significant explanatory powers, only three of the structural characteristics are statistically significant at the five percent level and one additional variable coefficient is statistically significant at the ten percent level. All variable coefficients are, however, of the hypothesized sign, with the notable exception being the distance to the landfill variable, which is positive. However, the coefficient is not significantly different from zero.

These results are interesting, to say the least. The landfill coefficient in Pepperell was the only coefficient to be statistically significant at even the ten percent level. There was no strong evidence of an effect of the landfill on surrounding property values in any of the other towns studied. An argument could be made that a one-tailed test could have been used, which would increase the estimated t-statistic in this model. However, we preferred to use two-tailed tests as they are more conservative.

8. Discussion

It is difficult to draw definitive policy conclusions from the results of this study. However, closer inspection of individual town models does provide some useful information. The Pepperell landfill has a statistically significant negative impact on property values. Although the landfill is not accepting waste, it is unlined and uncapped. In addition, the fact that the Pepperell landfill is on the EPA's "potential health risk" list may add to its visibility in the community. These factors make it highly likely that there is a positive willingness to pay to live further away from the landfill. However, this conclusion must also be regarded with some caution, since the Pepperell landfill is not the only disamenity in the area (and the model used a fairly small data set). Some large gravel pits are also located near the landfill, causing a potential "agglomeration diseconomies" effect. It is impossible to separate the effects of the landfill from the effects of the gravel pits (noise from trucks and operation, etc.).

An analysis of the Pepperell landfill's impact on property values shows that a typical house (a twenty year old house with 2 bedrooms, 4 other rooms, one and a half baths, a garage, lot size of 50,000 square feet and no pool or fireplace) located half a mile away from the landfill would experience a six percent rise in value when located a mile away from the landfill. Similarly, the same house one and a half miles away would increase in value by one percent when located two miles away. This price differential is not negligible; a six percent differential for a house valued at $120,000 (the approximate average value for the study) is $7,200.

Concerning the other five towns, although no statistically significant effects were found, it is possible that these effects do indeed exist but were not detected in this study, possibly due to the small sample sizes. The reader must keep in mind that some rather heroic assumptions have to be made in order for the estimated coefficient to adequately reflect the "willingness to pay" to live at a distance from the landfill. The assumption that perfect information exists in the market could easily be violated. People's perceptions of the landfill may be based on misinformation or ignorance. Unless there is a constant reminder of the landfill's presence, people may "forget" its existence. In many rural areas, the landfill is not easily visible. It may be tucked out of sight on a back road or by the next town's borders. Unlike urban areas, the landfill is not necessarily visually prominent. Recent research has indicated that knowledge of the location of nearby landfills can impact hedonic price estimates (Hite 1998).

Another point related to risk perceptions is addressed by Zeiss and Atwater (1989). Individuals have different risk preferences. Therefore, it might make sense that those who buy houses closer to the landfill are indifferent to the potential risk. In that case, the selling price would reflect the willingness to pay of the *risk - indifferent* buyer, but not that of the *risk averse* seller (Zeiss and Atwater 1989).

One assumption, which probably does not hold true, is that there are no transaction costs. A homeowner may be very concerned about the landfill near her house, but by moving she would incur substantial costs, including the uprooting of her family to a new community, a new school system, or possibly to a new job. These costs may well outweigh the marginal benefits of being further from the landfill.

In conclusion, this study does not provide grounds for broad generalization about the effect of rural landfills on property values. Six landfills were studied, each exhibiting different characteristics. It cannot be said that large landfills affect property values more than small, as Hudson is the largest landfill studied and its effect was statistically insignificant. Open landfills do not affect values more than closed, as the landfills in Hudson and Ware are still operating and show no effect. Landfills which seem to pose a threat to human health *may* affect property values more than others: Pepperell was, at the time of the study, on the EPA's list as potentially posing a threat to human health, but Belchertown and Clinton have been fined by the Massachusetts Department of Environmental Protection (MDEP) and could be, from the file reviews that were conducted at the appropriate regional office of the MDEP, to be at least as harmful. If the depreciation of local property values around the landfill is a concern of town officials, it seems that the best course of action would be to keep the landfill as clean and policed as possible. In the absence of any generalizations, it seems that each landfill should be studied on a case-by-case basis to determine whether it affects the surrounding property values.

In response to the NIMBY syndrome and to the fear of decreased property values, some policy makers have recommended compensatory programs. If residents are losing property value as a result of the siting or operation of a landfill, then perhaps they should be compensated in some way, on grounds of political expediency if not economic efficiency. These results show that such a compensatory program may not be warranted. Although town ownership of the land surrounding the landfill may be prudent for health and safety reasons, it may not be necessary to prevent the depreciation of property values.

Many town planners also consider closing their “town dump” and transporting their wastes to a facility in another town. Capping a landfill can be an expensive process (if municipally owned), and shipping the town’s waste to a regional facility can be an expense as well. The results of this study do not appear to justify this cost. Again, if the landfill should be closed due to health or safety concerns, then that expenditure may be warranted. However, as open landfills do not seem to have a larger effect than closed landfills, that action should not be taken based solely on the fear of property value depreciation.

Finally, the reader must be reminded that all the landfills studied were located in semi-rural towns. These results may not be generalizable to larger towns; indeed, it may be impossible to extrapolate these results to other regions at all. If the results demonstrate anything conclusively, it is that questions of landfills and property values should be studied on a case-by-case basis.

9. Suggestions for Further Research

Three main suggestions seem to arise from this study. The first two concern the availability of the data, which certainly could have been a factor in the statistical insignificance of the results. Almost by definition, rural areas do not have as many houses, and therefore not as much data, within two miles of the landfill as do urban areas. Therefore, expanding the number of years studied might be beneficial to the results. Similarly, pooling the towns would have increased the sample size, and might have allowed for a more precise estimate. Future researchers might attempt to study towns which *could* be pooled; perhaps towns more similar in income and socioeconomic status could be selected for study.

The third suggestion concerns the perceptions issue. Perceptions of landfill - associated risk are certainly an important determinant of willingness to pay to live further away from the landfill. Therefore, some sort of perception index might be useful in determining whether those perceptions translate into lower property values.

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